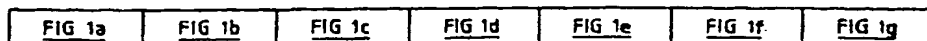




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(54) Title: HUMAN PERCENTAGE BODY FAT MEASURING TAPE



**(57) Abstract**

A measurement tape (10) for use in determining one or more body weight indicators, including at least two scales (24, 25, 26) of values of an extent to measure respective different body perimeters in terms of said values, the scales being non-linear with respect to length and predetermined whereby a useful body weight indicator may be obtained from a calculation utilising the measured values for the respective body perimeters.

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## HUMAN PERCENTAGE BODY FAT MEASURING TAPE

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**Field of the Invention**

This invention relates primarily to an anthropometric tape for use in determining one or more human body weight indicators, and to such use utilising the tape. The concept of the invention extends generally to a tape for a like purpose with other animals.

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**Background Art**

An important aspect of preventative medicine is a determination as to whether a person is underweight or overweight to an extent hazardous to the health and well-being of the person. It is well understood that absolute body weight must be considered with regard to the age, height and build of a person before any meaningful such determination can be made. A widely used weight indicator is weight versus height, and tables have been drawn up indicating desirable ranges for light framed, average and heavy framed types. Height versus weight graphs only measure standard weights for standard heights. Even the tables that divide people into differing frame sizes cannot determine what proportion of a person's body weight is healthy muscle and bone tissue and what proportion is unhealthy excess bodyfat tissue. Another problem with these types of tables is that people find it difficult to perceive what type of frame size they are. Many people include carrying excessive bodyfat in their perception of being large framed. These tables thus rely upon the perceptions of the individual and often these perceptions are totally incorrect.

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Another weight indicator is the ratio of weight (in kilograms) to height (in metres) squared, i.e.  $W/H^2$ , termed the Body Mass Index (BMI). This index is an attempted indication of a person's weight per surface area of skin, in order to obtain a further indication of their body density. Girth measurement monitoring is also employed to assess the change in inches or centimetres around certain body parts. These methods do not distinguish or differentiate between muscle and bone tissue weight, and bodyfat

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weight. Therefore, these methods are not reliable indicators of an individual possessing excess bodyfat.

An alternative approach is to make an assessment of percentage bodyfat as a more  
5 fundamental indicator which is broadly reliable regardless of build and age. Proposals for  
determination of % bodyfat have included skin fold measurement at various points on the  
body using skin fold callipers, which equates to subcutaneous fat levels (the quantitative  
version of the "pinch test"), and a variety of other anthropometric techniques involving  
10 determination of selected body perimeters. Conversion of such measurements to useful  
indicators have generally involved empirical non-linear relationships requiring multiple  
calculations. Substantial uncertainties due to large margins of error in skin fold  
measurement are also generally perceived to be a drawback, which make it difficult to  
achieve reproducible % bodyfat values from skin fold measurement techniques.

15 The most accurate known clinical method for determining % bodyfat is  
hydrostatic weighing. The subject is first weighed on accurate scales, and then seated on  
a weight measuring platform in a larger receptacle containing a known quantity of water.  
The subject blows all of the air from the lungs and then submerges body and head under  
water for about 5 seconds. A computer compares the subject's weight on land and weight  
20 in water, assesses the volume of water displaced by the subject's body, calculates the  
body density of the subject, and from this derives a % bodyfat value. The margin of error  
is around 2% in young to middle-aged adults, but is less accurate for children, older  
adults and extremely lean people. For the method to be accurate, the subject must blow  
out all of the air that is in the lungs, a difficult task for some people. A significant  
25 difficulty is that hydrostatic weighing requires specialised equipment and is only  
available at some universities and sports research facilities.

A method related to hydrostatic weighing uses a "Bod Pod", a 5-foot tall  
fibreglass egg-shaped chamber in which a subject sits on a weight sensitive platform  
30 while electronic sensors measure how much air the subject displaces.

In a bio-electrical impedance method, the subject lies on his or her back with electrodes connected to a hand and a foot in a similar fashion to having an ECG. An electric impulse is sent through the subject's body and the time taken to get from hand to foot is measured. This method works on the theory that electricity travels faster through muscle (approximately 70% water) than through fat (approximately 10% water), but the test is not very accurate and large margins of error have been reported. The state of hydration is critical and therefore the subject must be certain that he or she is not over hydrated (or dehydrated) at the time of measurement.

10. It is an object of the invention to facilitate the determination of one or more body weight indicators.

#### **Summary of the Invention**

The invention provides a measurement tape for use in determining one or more body weight indicators, in one advantageous aspect an anthropometric tape for use in determining one or more human body weight indicators, including at least two scales of values of an extent to measure respective different body perimeters in terms of said values, the scales being non-linear with respect to length and predetermined whereby a useful body weight indicator may be obtained from a calculation utilising the measured values for the respective said body perimeters.

From this useful body weight indicator, other useful body weight indicators may be derived with the additional knowledge of the subjects total (or absolute) body weight.

25. Preferably, there are three scales of values, two of which are selected to measure respective body perimeters at locations where fat tends to preferentially deposit, and a third which is selected to measure a body perimeter at a location where the measured value is indicative of degree of muscularity and skeletal build.

30. Preferably, the scales are specific to either males or females, or the tape includes different scales for males and females, for example on opposite faces. For example, in the case of males, the aforementioned perimeters at locations where fat tends to preferentially

deposit are preferably in the region of the waist and the hips, and the third perimeter is preferably a forearm perimeter, preferably on the dominant arm. For females, the aforementioned perimeters at locations where fat tends to preferentially deposit are preferably in the region of the waist and a thigh perimeter, while the third is preferably a calf perimeter. The thigh and calf measured are advantageously selected according to the handedness of the person. The forearm on males and calf on females are regions that reflect more the degree of muscularity and skeletal build than bodyfat.

Advantageously, two of the scales are provided in a common band portion of the tape at opposite lateral edges of the tape.

Preferably, the useful body weight indicator obtained from the calculation is % bodyfat. The values of the scales are preferably arranged so that the calculation by which the useful body weight indicator is obtained is a simple sum involving addition and/or subtraction of the values. The tape advantageously includes a printed representation of the calculation and may further include a scale indicating ranges of the body weight indicator specified as, eg. underweight, lean, acceptable, overweight and obese.

It will be understood that the invention stems from an appreciation that useful scales of the kind envisaged can be derived, ie. that a useful non-linear relationship can be indicated between body perimeters and values ultimately able to be utilised to determine a body weight indicator, e.g. % bodyfat.

The invention further provides a method of determining one or more body weight indicators e.g. % bodyfat, including utilising the aforementioned tape to measure plural body perimeters in terms of respective values of the scales on the tape, and obtaining the body weight indicator from a calculation utilising the measured values for the respective said body perimeters.

The invention further extends to an anthropometric set including one or more measurement tapes according to the invention and instructions for carrying out a method of measurement, e.g. that of the invention, utilising the tape(s). The set preferably

includes two of said measurement tapes, one specific to females and another specific to males. The instructions advantageously include a scale indicating ranges of the body weight indicator specified as, e.g. underweight, lean, acceptable, overweight and obese.

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### **Brief Description of the Drawings**

The invention will now be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a plan view diagram of an anthropometric tape according to an embodiment of the invention, for determining % bodyfat in males; and

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Figure 2 depicts a similar tape used for determining % bodyfat in females.

In each of Figures 1 and 2, the tape is shown fragmented into four sections. The right end of each depicted section links to the left end of the next section underneath. A little overlap is shown. Each figure includes a reference cm scale to allow correlation of the illustrated non-linear scales with actual tape size.

15

### **Preferred Embodiments**

The tape 10 illustrated in Figure 1 is an elongate band of vinyl reinforced with cloth fibres, on which band is printed the illustrated scales and other matter. Other materials may be employed for the tape, e.g. plasticised paper with a vinyl or polyester coating, but the material of the tape is selected to be stable in length and non-stretchable in normal use. The tape may typically be about 1.35 metres in length, sufficient to extend around the hips of a person of large girth, and would normally be presented as an anthropometric set including tape 10 for determining % bodyfat in males, a corresponding tape 10' (Figure 2) for determining % bodyfat in females, and an instruction booklet explaining use of the tapes and derivation of % bodyfat and other body weight indicators by use of the tapes. For convenience, this instruction booklet is not illustrated, but certain tables from the booklet are included hereinafter.

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Commencing from the left or start end 11, each tape 10, 10' includes a segment 22 diagrammatically illustrating a calculation in the form of a simple sum, and three scales of values 24, 25, 26 indicated by the letters A, B and C printed on the tape (and also by

colour but this is not evident in the drawing). Segment 22 is shown a little enlarged relative to the other parts of the tape, in order to clarify the printing, but is in fact of the same width. Scales 24,25,26 comprise spaced printed integers and related bold line marks 40 providing a primary gradation, and intermediate fine line marks 42 dividing each primary gradation into quarter segments. Associated further scales concerned with indicating various ranges or categories of % bodyfat are contained in the instruction booklet and are appended hereto as Table 1 and Table 2 for males and females respectively.

The respective scales are to an extent to measure different body perimeters in terms of the values on the scales, which are non linear with respect to length and are predetermined whereby % bodyfat, as a useful body weight indicator, may be obtained from the calculation illustrated in segment 22, utilising the measured values for the respective body perimeters. The illustrated sum in tape segment 22 depicts the correct perimeter to be measured on each scale, and text on each scale further clarifies the locations. In the case of tape 10, which is for use with males, scale 24/A is for measuring in the region of the waist, in particular the relaxed abdominal circumference 1 cm above the belly button as stated on the scale on the tape. Scale 25/B is for measurement in the hips region, in particular the maximum buttocks/hips circumference with the heels together. It will be seen that scales 24/A and 25/B are on the same band portion of the tape at opposite lateral edges 24a, 25a. Each of these scales extends from an intermediate position 27 through to the right end 29 of the tape, but the reference or start line, for each of the scales is the left end 11 of the tape : the tape is looped firmly around the respective body location and the point which line 11 marks is the scale reading.

Scale 26/C is quite different and measures a forearm perimeter, specifically the maximum forearm circumference, ie. the widest reading between the elbow and wrist, of the dominant arm. By "dominant" is meant the right arm in right-handed people and the left arm in left-handed people. Scale 26/C is along lateral edge 24a, between segment 22 and scale 24/A, and the reference line is again tape start end 11.



It has been recognised that in men bodyfat is specifically stored around the midriff. Thus, the abdominal and hip circumferences are broadly indicative of bodyfat proportion because, in males, these are preferential locations for the deposit of bodyfat. On the other hand, it has been further recognised that the forearm in males tends to be low in bodyfat so that its circumference is a good indicator of degree of muscularity and skeletal build. Hence the total score obtained by adding the abdominal and buttocks scores is compensated for body type by subtracting the score for the maximum dominant forearm measurement, which is a part of the body that does not tend to store bodyfat and is therefore a reflection of the person's bone size and muscularity. It will be noted that height is not correlated with either bodyfat deposition or bone density and muscularity.

The values on the three scales will be seen to be rather irregular but to exhibit some broadly cyclic behaviour. They have been determined by a mixture of accumulated empirical observation from a range of subject individuals and references to known tables, and are chosen so that the diagrammatically represented calculation in tape segment 22,  $A + B - C$ , will give a reliable broad indication of % bodyfat for male subjects, at least within the margin of error discussed below.

Table 1 provides a linear scale of bodyfat percentages and fractions from 6% to 53% (0.06 to 0.53) with primary qualitative ranges (underweight, lean, acceptable, overweight and obese) indicated by successive grey-level bands. An ideal weight range is also shown. It will of course be appreciated that the indicated boundaries of the selected ranges are to some extent a matter of medical opinion and that different experts in the field or future professional scrutiny may ascribe other boundaries, or may further subdivide the indicated ranges.

Table 3 sets out directions for obtaining a number of additional body weight indicators, including mass of bodyfat, lean body mass, desirable body weight range, and excess bodyfat.

Figure 2 (in which like elements are indicated by like primed reference numerals) illustrates a corresponding tape 10' for determining % bodyfat in females. It will be seen

that the general layout of the tape is broadly similar, except that the two of scales are for measuring different perimeters and are arranged a little differently. In this case, the A' scale 24' is again for measuring in the region of the waist, in particular the relaxed abdominal circumference 1 cm above the belly button as stated on the scale on the tape.

5 The B' scale 25' is for measuring an upper thigh circumference, more specifically at the level where the thigh intersects the buttocks; the choice of which thigh is related to the handedness of the person in the sense that a left-hand person should measure the left thigh and a right-handed person the right thigh. The C' scale 26' is for measuring a mid-calf perimeter, preferably at a level half way between the ankle and the knee; again the  
10 choice of the which leg is dependent as indicated in Figure 2 on the handedness of the person. These choices have been made for reasons similar to the perimeters chosen for scales A, B and C of the male tape, and the calculation is again a simple sum involving addition and subtraction,  $A' + B' - C'$ .

15 As with Figure 1, the reference or start line for each scale is the start or left end 11' of tape 10'. Scale 25'/B' is at one lateral edge 25a', while scales 24'/A' and 26'/C' are at the opposite edge 24a'. Table 2 is the female counterpart of Table 1, while Table 3 applies to male or female determinations.

20 Other body perimeters which might be alternatively used on different tape scales include, without limitation, chest wall circumference, wrist circumference, and ankle circumference. In modified embodiments, the information of Tables 1 and 2 is included in an additional printed tape segment, and/or the summation of tape segment 22 is not on the tape but in an associated booklet or software package.

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It is thought that the initial margin of error in the use of the illustrated tapes and their scales as depicted (allowing for the reference cm scale in each case) is up to  $\pm 3\%$  bodyfat for most people. While less accurate than the aforescribed hydrostatic technique, the described method may be readily and simply performed by a subject at any  
30 time and in any place. Once on initial % bodyfat value is derived, subsequently measured changes can be better than  $\pm 3\%$  provided the subject is consistent in the selected locations for the respective measurements.

It will be understood that the invention disclosed and defined herein extends to all alternative combinations of two or more of the individual features mentioned or evident from the text or drawings. All of these different combinations constitute various  
5 alternative aspects of the invention.

It will also be understood that the term "comprises" or its grammatical variants as used herein is equivalent to the term "includes" and is not to be taken as excluding the presence of other elements or features.



Table 3

<b>% Bodyfat</b>	calculate your % bodyfat by using your tape and find it in the respective range table above.
<b>Bodyfat Weight (BFW)</b>	calculate your kilograms of bodyfat by multiplying your total body weight in kilograms by your % bodyfat reading and then divide this number by 100.
<b>Lean Body Mass (LBM)</b>	calculate your lean body mass (weight of your muscles, internal organs and bones) by subtracting your kilograms of bodyfat from your total weight in kilograms.
<b>Ideal Weight Range</b>	calculate what your total body weight should be to place you within the lean and acceptable weight range. Multiply your lean body mass by 1.10 for males, 1.15 for females, then your lean body mass by 1.32 for males, 1.39 for females. This is your ideal weight range.
<b>Excess Bodyfat</b>	calculate your excess bodyfat in kilograms by subtracting the largest value of your ideal weight range from your total body weight.

## Claims

1. A measurement tape for use in determining one or more body weight indicators, including at least two scales of values of an extent to measure respective different body  
5 perimeters in terms of said values, the scales being non-linear with respect to length and predetermined whereby a useful body weight indicator may be obtained from a calculation utilising the measured values for the respective body perimeters.
2. A measurement tape according to claim 1, being an anthropometric tape for use in  
10 determining one or more human body weight indicators.
3. A measurement tape according to claim 2 wherein at least a first of said values is selected to measure a body perimeter at a location where fat tends to preferentially deposit, and at least a second of said values is selected to measure a body perimeter at a  
15 location where the measured value is indicative of degree of muscularity and skeletal build.
4. A measurement tape according to claim 2 wherein there are three of said scales of values, two of which are selected to measure respective body perimeters at locations  
20 where fat tends to preferentially deposit, and a third which is selected to measure a body perimeter at a location where the measured value is indicative of degree of muscularity and skeletal build.
5. A measurement tape according to claim 4 wherein said scales include scales  
25 specific to males, said perimeters at locations where fat tends to preferentially deposit are in the region of the waist and hips, and said third perimeter is a forearm perimeter.
6. A measurement tape according to claim 5 wherein said forearm perimeter is on the dominant arm.

7. A measurement tape according to claim 4 wherein said scales include scales specific to females, said perimeters at locations where fat tends to preferentially deposit are in the region of the waist and a thigh, and said third perimeter is a calf perimeter.

5 8. A measurement tape according to claim 7 wherein said calf and thigh perimeters are selected according to the handedness of the person.

9. A measurement tape according to any one of claims 1 to 4 wherein said scales are specific to either males or females.

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10. A measurement tape according to claim 9 wherein the tape includes different said scales for males and females.

11. A measurement tape according to any preceding claim wherein two of said scales  
15 are provided in a common band portion of the tape at opposite lateral edges of the tape.

12. A measurement tape according to any preceding claim wherein said useful body weight indicator obtained from the calculation is % bodyfat.

20 13. A measurement tape according to any preceding claim wherein said values of the scales are arranged so that the calculation by which the useful body weight indicator is obtained is a simple sum involving addition and/or subtraction of the values.

14. A measurement tape to claim 13 wherein the tape includes a printed  
25 representation of the calculation.

15. A measurement tape according to any preceding claim wherein said tape further includes a scale indicating ranges of the body weight indicator specified as, e.g., underweight, lean, acceptable, overweight and obese.

16. An anthropometric set including one or more measurement tapes according to any one of claims 1 to 15 and instructions for determining one or more body weight indicators utilising the tape.

5 17. An anthropometric set according to claim 16 wherein there are two of said measurement tapes, one specific to females and another specific to males.

18. An anthropometric set according to claim 16 or 17 wherein said instructions include a scale indicating ranges of the body weight indicator specified as e.g.,  
10 underweight, lean, acceptable, overweight and obese.

19. An anthropometric set according to claim 16, 17 or 18 wherein said useful body weight indicator obtained from the calculation is % bodyfat.

15 20. A method of determining one or more body weight indicators, including utilising a measurement tape according to any one of claims 1 to 15 or an anthropometric set according to any one of claims 16 to 19.

21. A method according to claim 20 wherein said useful body weight indicator  
20 obtained from the calculation is % bodyfat.



<u>FIG 1a</u>	<u>FIG 1b</u>	<u>FIG 1c</u>	<u>FIG 1d</u>	<u>FIG 1e</u>	<u>FIG 1f</u>	<u>FIG 1g</u>
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FIG 1

<u>FIG 2a</u>	<u>FIG 2b</u>	<u>FIG 2c</u>	<u>FIG 2d</u>	<u>FIG 2e</u>	<u>FIG 2f</u>	<u>FIG 2g</u>
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FIG 2



FIG 1a

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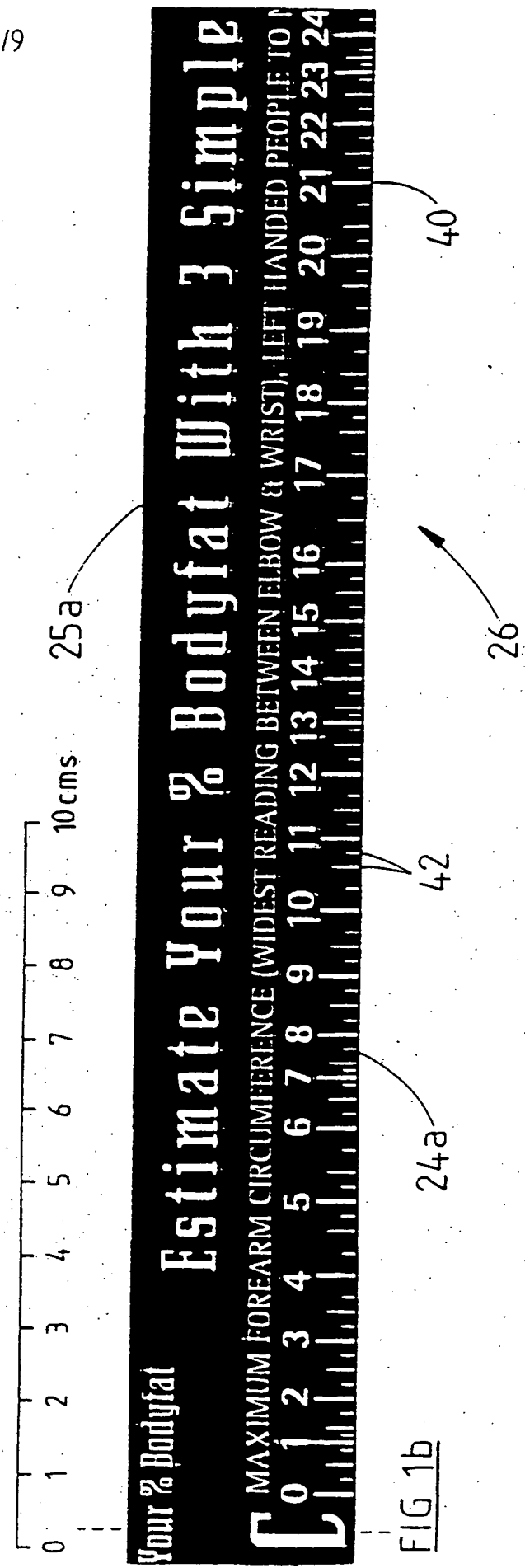
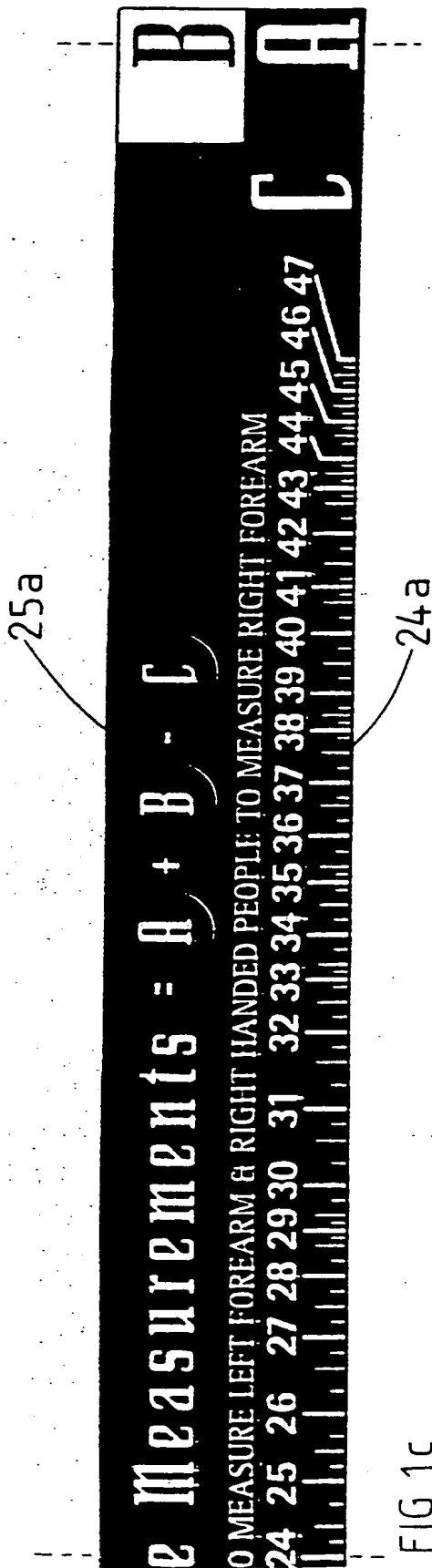
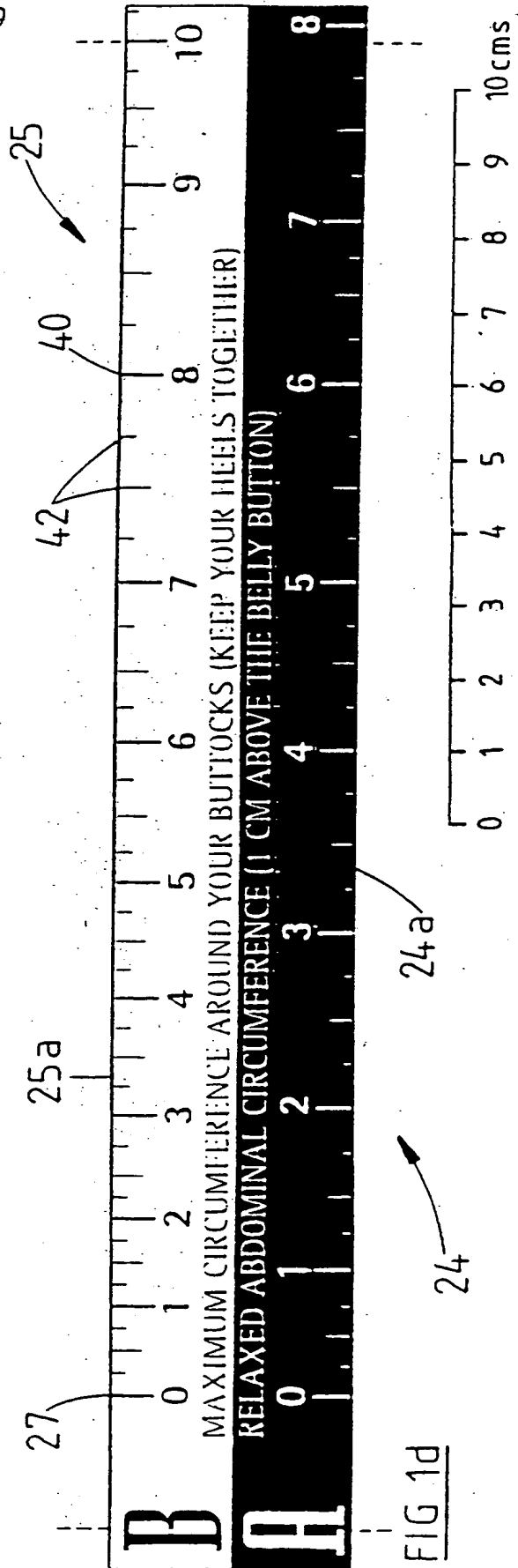
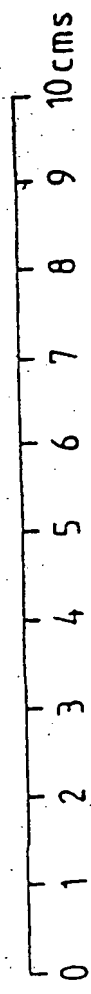
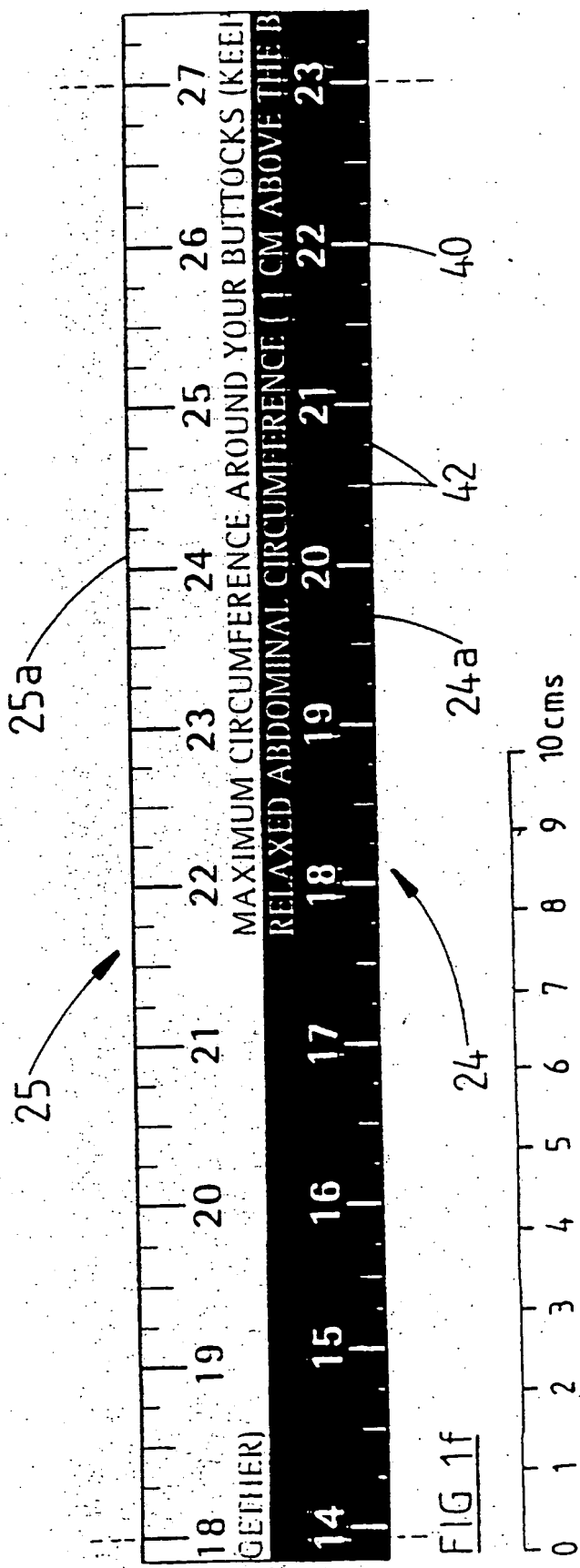
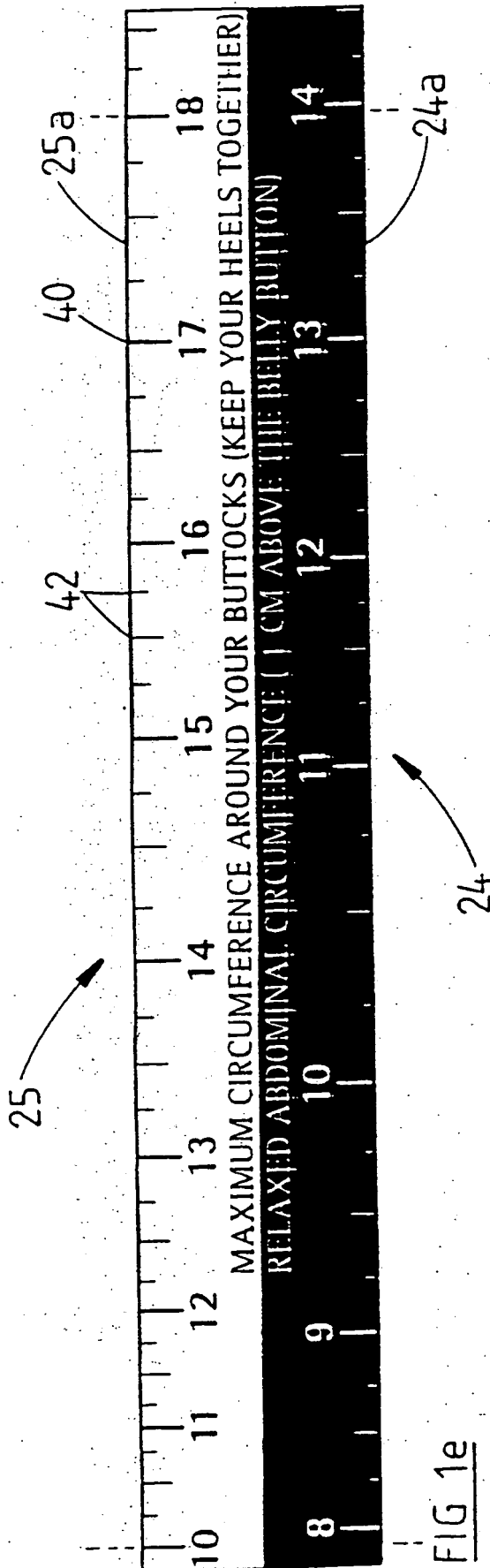


FIG 1b

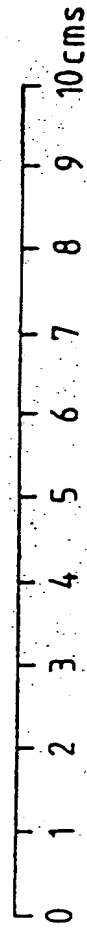
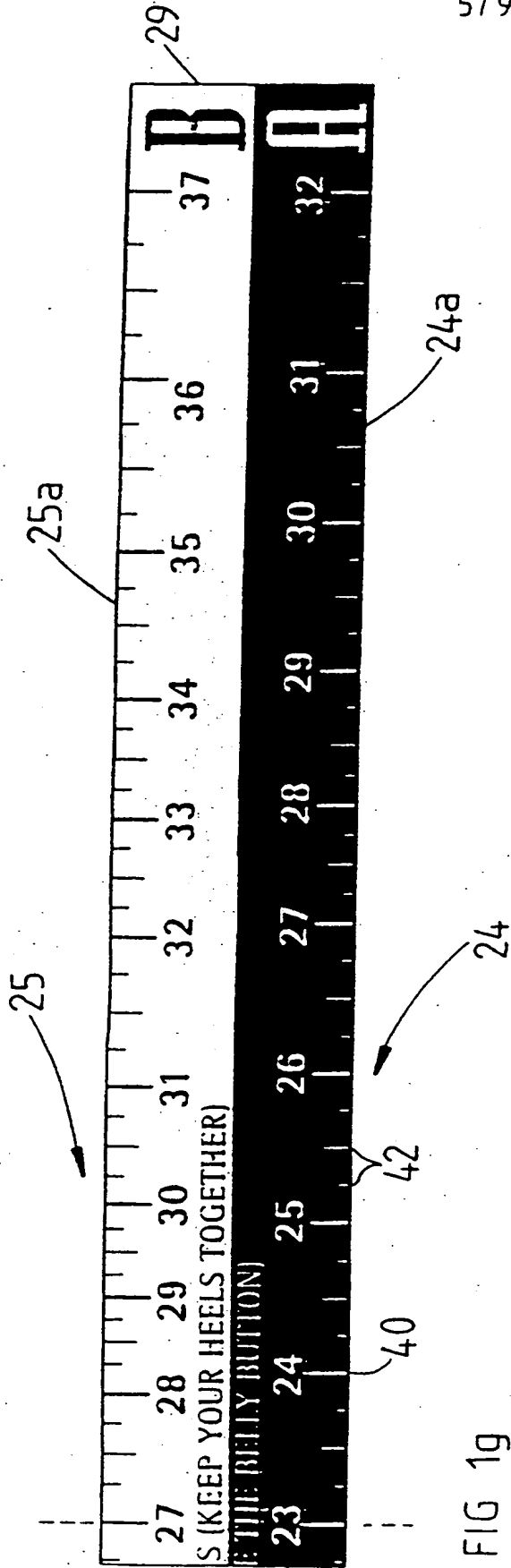


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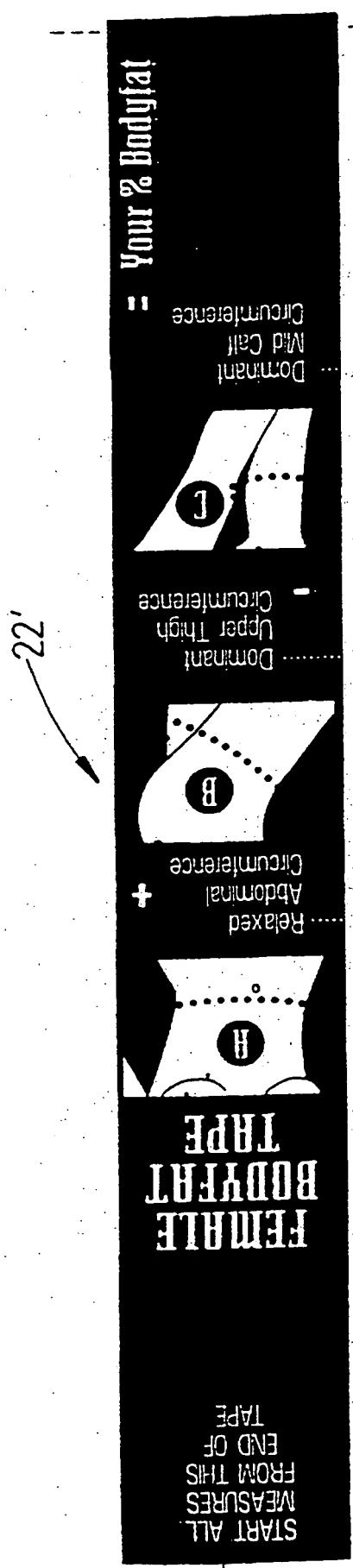
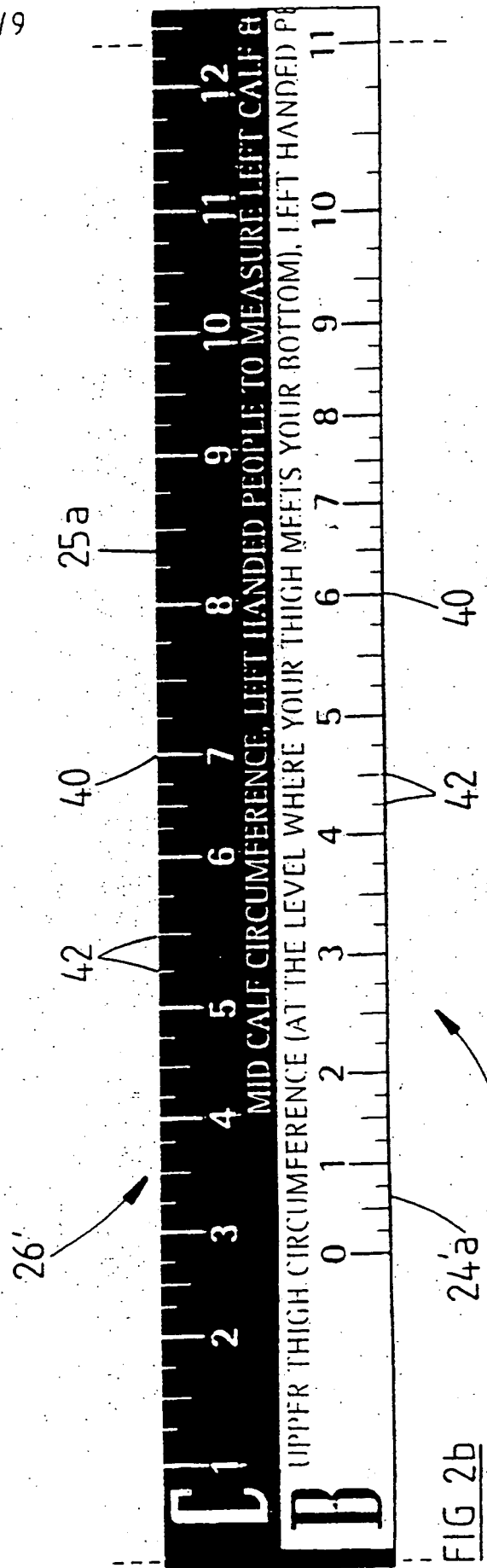


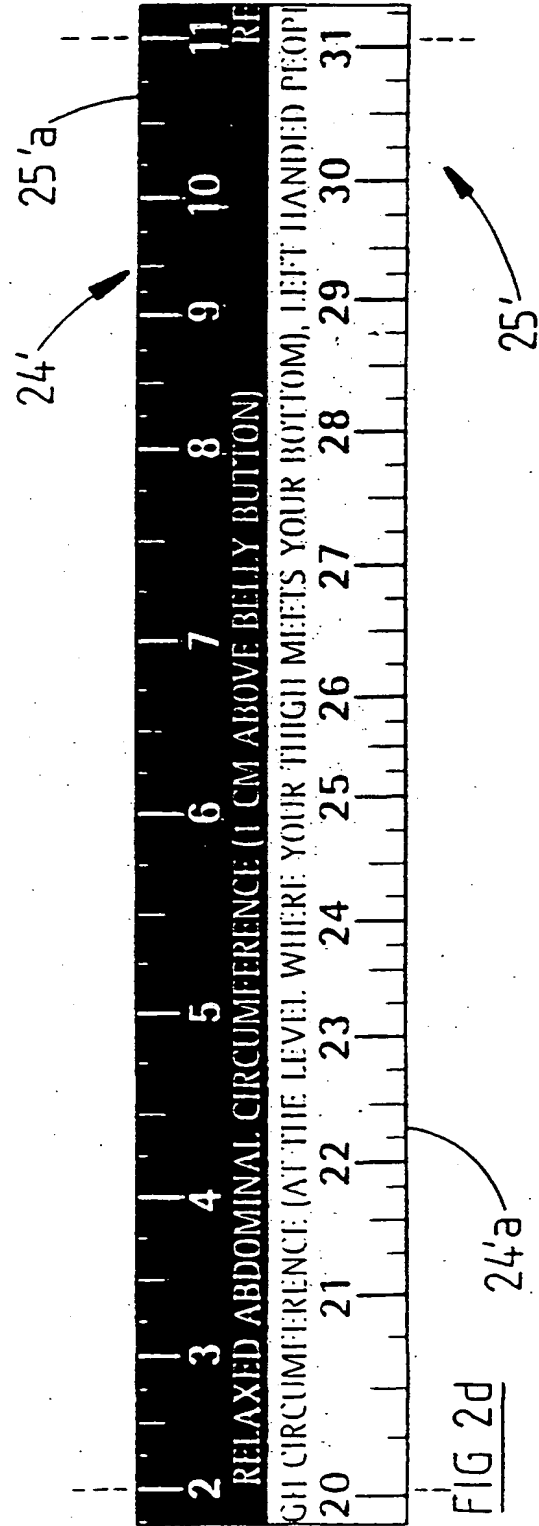
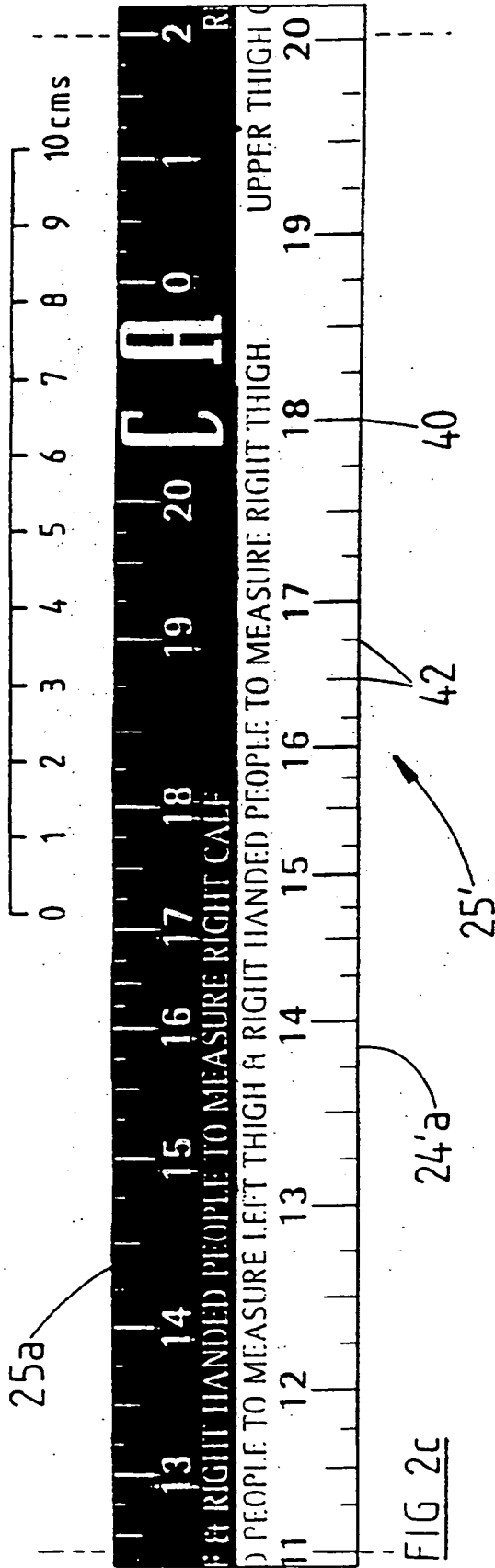
FIG 2a

0 1 2 3 4 5 6 7 8 9 10 cms

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7/9



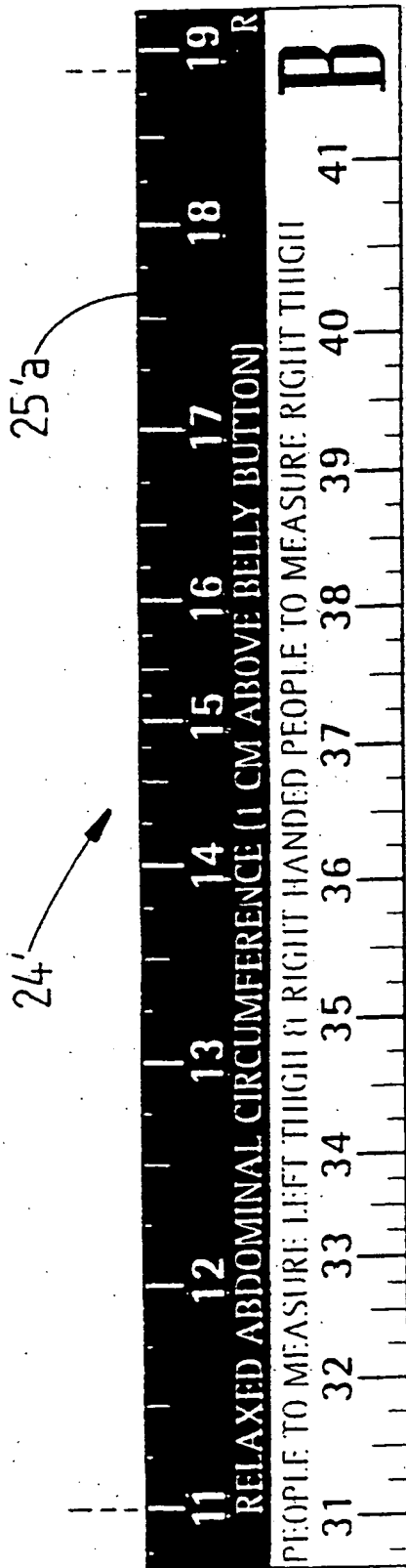


FIG 2e

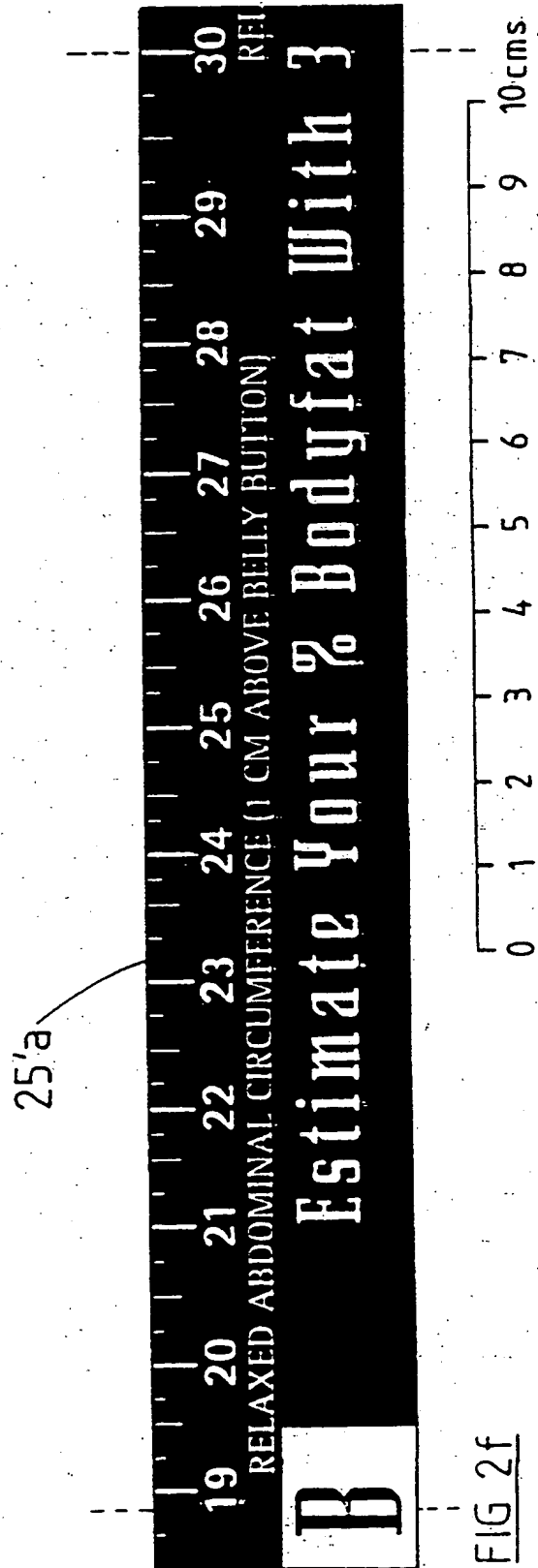


FIG 2f



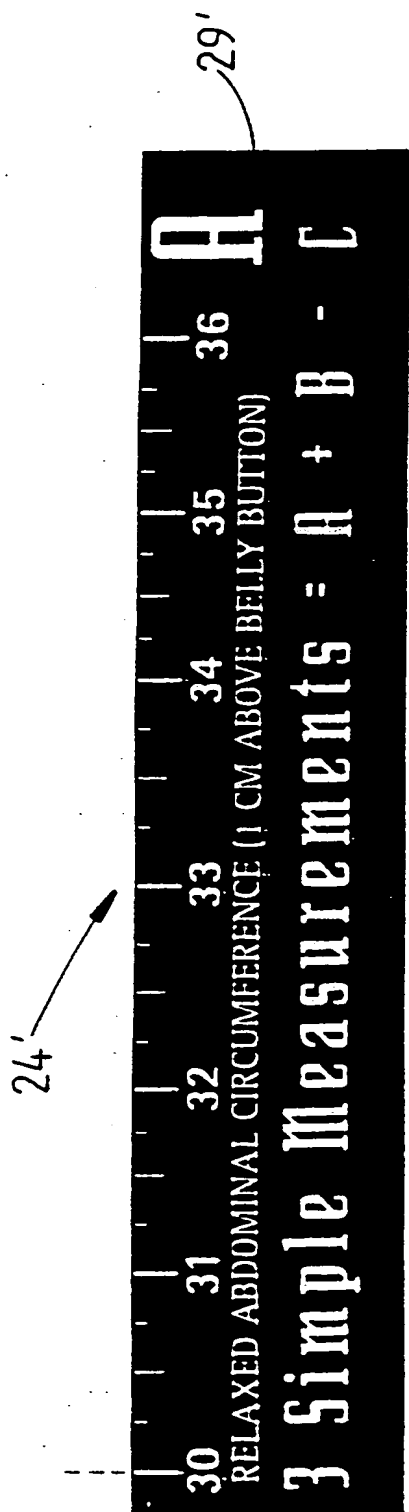
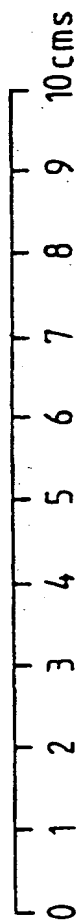


FIG 2g



<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
Int Cl <sup>6</sup> : A61B 5/107, G01B 3/10		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) IPC: A61B 5/-, G01B 3/-		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched AU IPC: as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) WPAT, JAPIO: (ANTHROP: OR BODY OR BODIES OR PHYSICAL: OR PHYSIQUE# OR LIMB# OR GIRTH# OR HIP# OR ARM#) and (TAPE# OR SCALE# OR BAND#) and (MEASUR: OR INDICAT: OR DIAGN: OR DETERMIN: OR CALCULAT:) and (FAT# OR WEIGH: OR MUSC: OR SKELET: OR MASS OR BODYFAT# OR UNDER (W) WEIGHT: OR OVER (W) WEIGHT: OR OBES: OR SIZE)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2213936 A (BROSELOW) 23 August 1989 see page 4 lines 4 to 11 and page 6 lines 10 to 12	1-20
P,A	US 5595189 A (NAIM ET AL.) 21 January 1997	
P,A	US 5588215 A (HART) 31 December 1996	
<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="text-align: center;"> <input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C         </div> <div style="text-align: center;"> <input checked="" type="checkbox"/> See patent family annex         </div> </div>		
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p> </div> </div>		
Date of the actual completion of the international search 23 September 1997		Date of mailing of the international search report <b>01 OCT 1997</b>
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929		Authorized officer  <b>PETER T. WEST</b> Telephone No.: (02) 6283 2108

## INTERNATIONAL SEARCH REPORT

International Application No.

PCT/AU 97/00551

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5156161 A (LOLLAR) 20 October 1992	
A	US 4321752 A (KAUFMAN) 30 March 1982	
A	GB 2179743 A (CARRINGTON VIYELLA GARMENTS LIMITED) 11 March 1987	
A	WO 92/14116 A1 (FRIBERG) 20 August 1992	

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
GB	2213936	US	4823469	EP	220860	CA	1313041
		EP	343874				
US	5595189	NONE					
US	5588215	NONE					
US	5156161	AU	24217/92	EP	616506	WO	9302620
US	4321752	NONE					
GB	2179743	NONE					
WO	9214116	AU	12421/92	EP	570459	SE	9100387